Contract Report 550

Reduction and Adjustment of Water Year 1986 Precipitation Data for Lake Michigan Diversion Accounting

By Randy A. Peppier
Office of the Chief

Prepared for the
Illinois Department of Transportation,
Division of Water Resources

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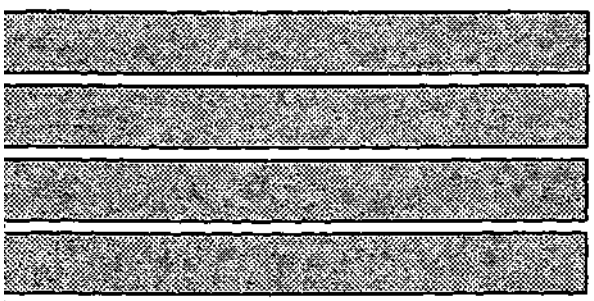

Illinois State Water Survey
Administration Division
Champaign, Illinois

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Introduction

The volume of water diverted from Lake Michigan into the State of Illinois is monitored to ensure that the diversion does not exceed a limit of 3,200 cubic feet per second when computed over a long-term mean, as imposed by a U.S. Supreme Court Order in 1967. An important component of the monitoring procedure is the accurate representation of the precipitation that falls over the diverted Lake Michigan and Des Plaines River watersheds of northeastern Illinois. These precipitation values are needed as input to a hydrologic model used to compute storm runoff, which is considered part of the diversion.

Precipitation patterns from raingages used for diversion accounting in the Cook County region during Water Years 1984-1985 (a water year runs from 1 October through 30 September of the following calendar year) were found to be unusual compared to previous known patterns of Chicago-area precipitation (e.g., Changnon, 1961, 1968; Huff and Changnon, 1973; Vogel, 1988, 1989). These patterns were caused mostly by unusually low water year totals at a number of the gages when compared to other gages in the Chicago area and northeastern Illinois. Inspection of these sites (Vogel, 1988) revealed that the unusual patterns were caused by 1) poor raingage exposure (rooftop exposures with nearby obstructions, in most cases) and 2) different practices for observations, maintenance, data reduction, and quality control by the different groups responsible for maintaining the raingages. Vogel (1988) established that unusual

distributions of precipitation began to occur in 1967, with precipitation amounts decreasing markedly at some of the sites in the area, corresponding to raingage relocations to sites with poorer exposures than before. Patterns from Water Year 1986 again exhibited an unusual precipitation pattern. Figure 1 shows the raw, unadjusted analysis for this water year, with lows in precipitation amounts in southeastern Cook County and along the lakeshore in the downtown area, and precipitation highs in western and southwestern Cook County. Values range from an anomalously low 21.97 inches in the southeast and 29.95 inches along the lakeshore to a much higher (and likely accurate) 42.10 inches in the west-southwest.

The accounting procedure carried out by the U.S. Army Corps of Engineers (COE), Chicago District, requires hourly, high-quality precipitation measurements to compute the storm runoff portion of the diversion of water away from Lake Michigan. Thus, Vogel (1988) devised a procedure to adjust questionable precipitation data and make them suitable for use in the accounting procedure. This same procedure was used to adjust data collected during Water Year 1986. Amount and percentage adjustments at each station and a modified spatial precipitation pattern for the water year are also presented in this report.

Raingages and Data

Thirteen raingages were used during Water Year 1986 to measure precipitation as subsequent input to storm runoff calculations for Lake Michigan diversion accounting (Table 1). All the recording devices except for the one at Park Forest provide hourly amounts. The raingages are managed by three different organizations: 1) the National Weather Service (NWS); 2) the City of Chicago (CC); or 3) the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC).

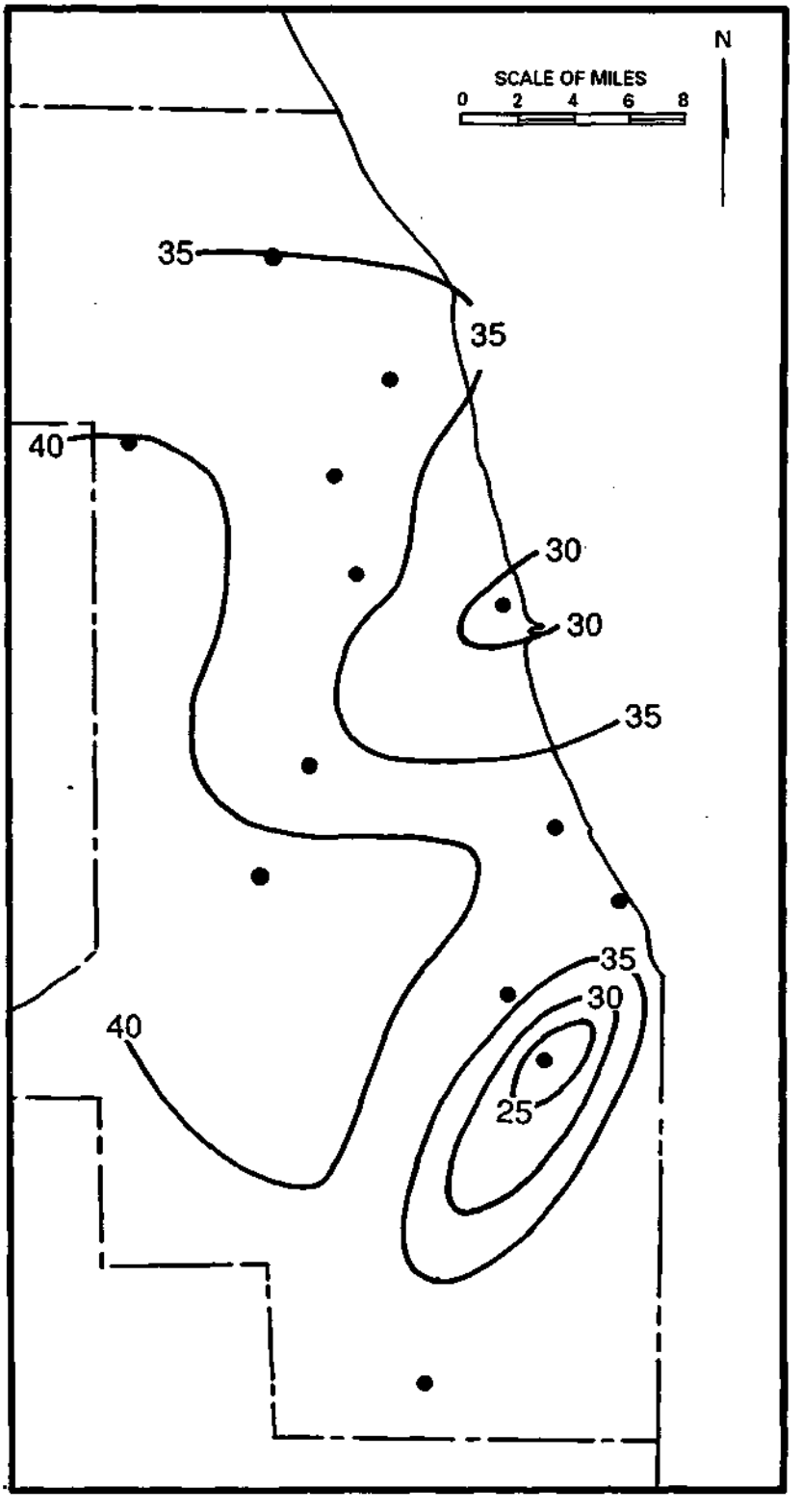

Figure 1. Water Year 1986 precipitation pattern (inches) from original records. Dots indicate raingage locations.

Table 1. Raingages in Cook County and Northeastern Illinois - Water Year 1986

Raingages Used in Accounting Procedure	
Glenview (MWRDGC)	South WPP (CC)
Skokie North Side STP (MWRDGC)	Roseland WPP (CC)
Erie SDO (MWRDGC)	Chicago O'Hare Airport (NWS)
West Southwest STP (MWRDGC)	Chicago University (NWS)
Calumet STP (MWRDGC)	Midway 3 SW (NWS)
Mayfair WPP (CC)	Park Forest (NWS)
Springfield WPP (CC)	

Additional Raingages Used in Analysis	
Antioch (NWS)	Jardine WPP (CC)
Waukegan (NWS)	Wheaton (NWS)
McHenry (NWS)	Aurora (NWS)
Marengo (NWS)	Joliet/Brandon Road Dam (NWS)
Barrington (NWS)	Channahon/Dresden Island (NWS)
Chicago Botanical Garden (NWS)	Peotone (NWS)
Elgin (NWS)	

Notes:

MWRDGC	= Metropolitan Water Reclamation District of Greater Chicago
CC	= City of Chicago
NWS	= National Weather Service
STP	= Sewage Treatment Plant
PS	= Pumping Station
WPP=	= Water Purification Plant
SDO=	= Sanitary District Office

Three different recording raingage types are used: universal weighing buckets, Fischer-Porter weighing buckets, and tipping buckets. The NWS raingages at Chicago O'Hare Airport and the University of Chicago are universal weighing buckets measuring to the nearest hundredth of an inch. The Midway 3 SW gage is a Fischer-Porter weighing bucket measuring to the nearest tenth of an inch. The CC and MWRDGC gages are tipping buckets measuring to the nearest hundredth of an inch. A daily measurement was made at the 8-inch nonrecording stick raingage at the NWS Park Forest site. The spatial distribution of these raingages is given in Figure 2. The other NWS sites listed on the lower panel of Table 1 also use nonrecording stick devices.

Hourly precipitation data from NWS raingages for Water Year 1986 were obtained from *Hourly Precipitation Data, Illinois,* published by the National Climatic Data Center (NCDC). Daily precipitation amounts for Park Forest and for the other nonrecording NWS sites used in the analysis were acquired from *Climatological Data, Illinois,* also published by the NCDC. Hourly precipitation values from the CC and MWRDGC raingages were provided by those organizations. In addition to adjusting questionable data, the procedure developed by Vogel also replaces missing values with estimates made using available information from neighboring raingages in the analysis.

To generate more meaningful spatial storm patterns, the hourly data at Jardine WPP (CC) and the daily data at the other NWS sites in northeastern Illinois were plotted and analyzed in addition to the 13 stations specifically used for diversion accounting purposes. All stations are shown in Figure 3.

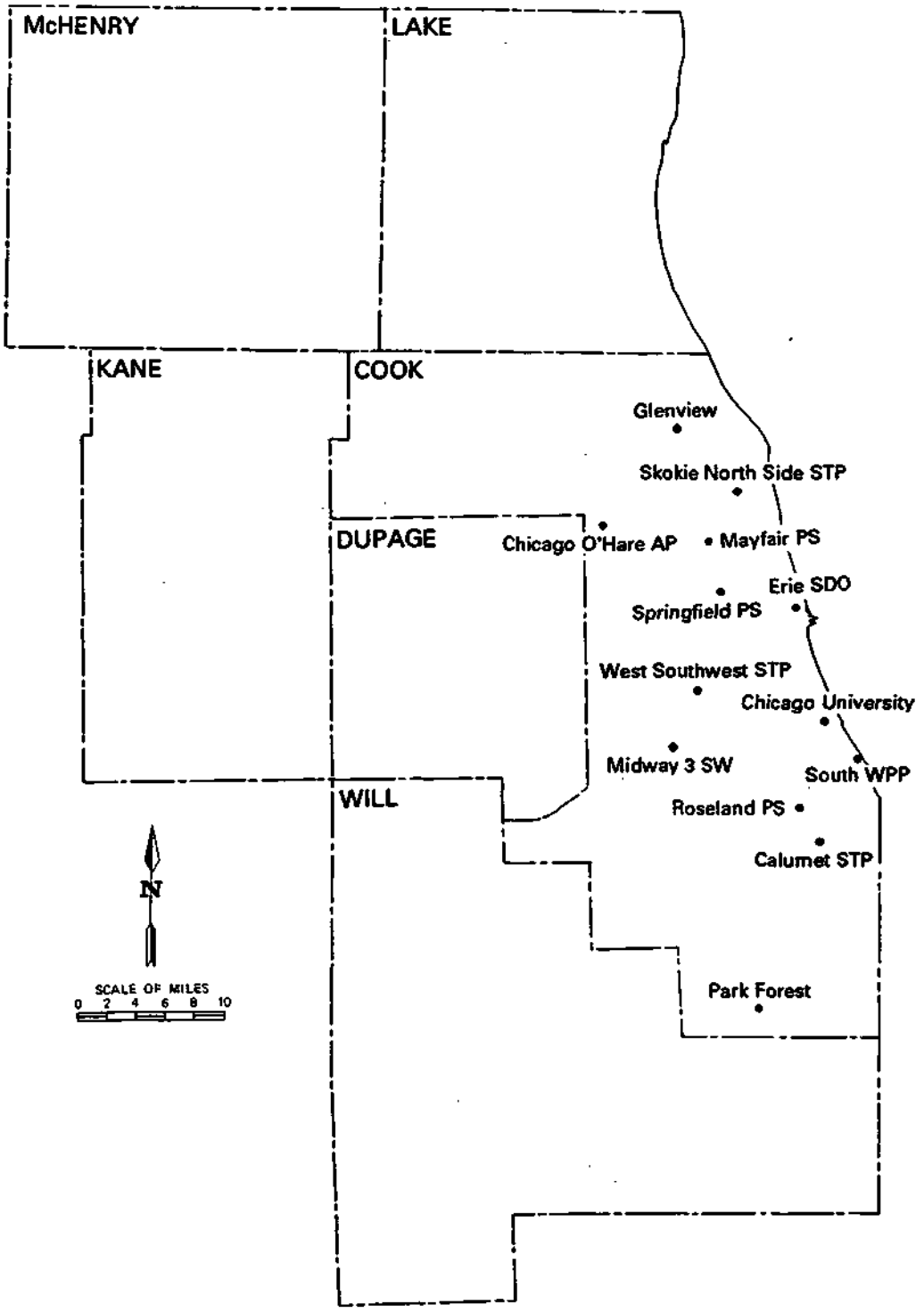

Figure 2. Raingage sites used in the accounting procedure.

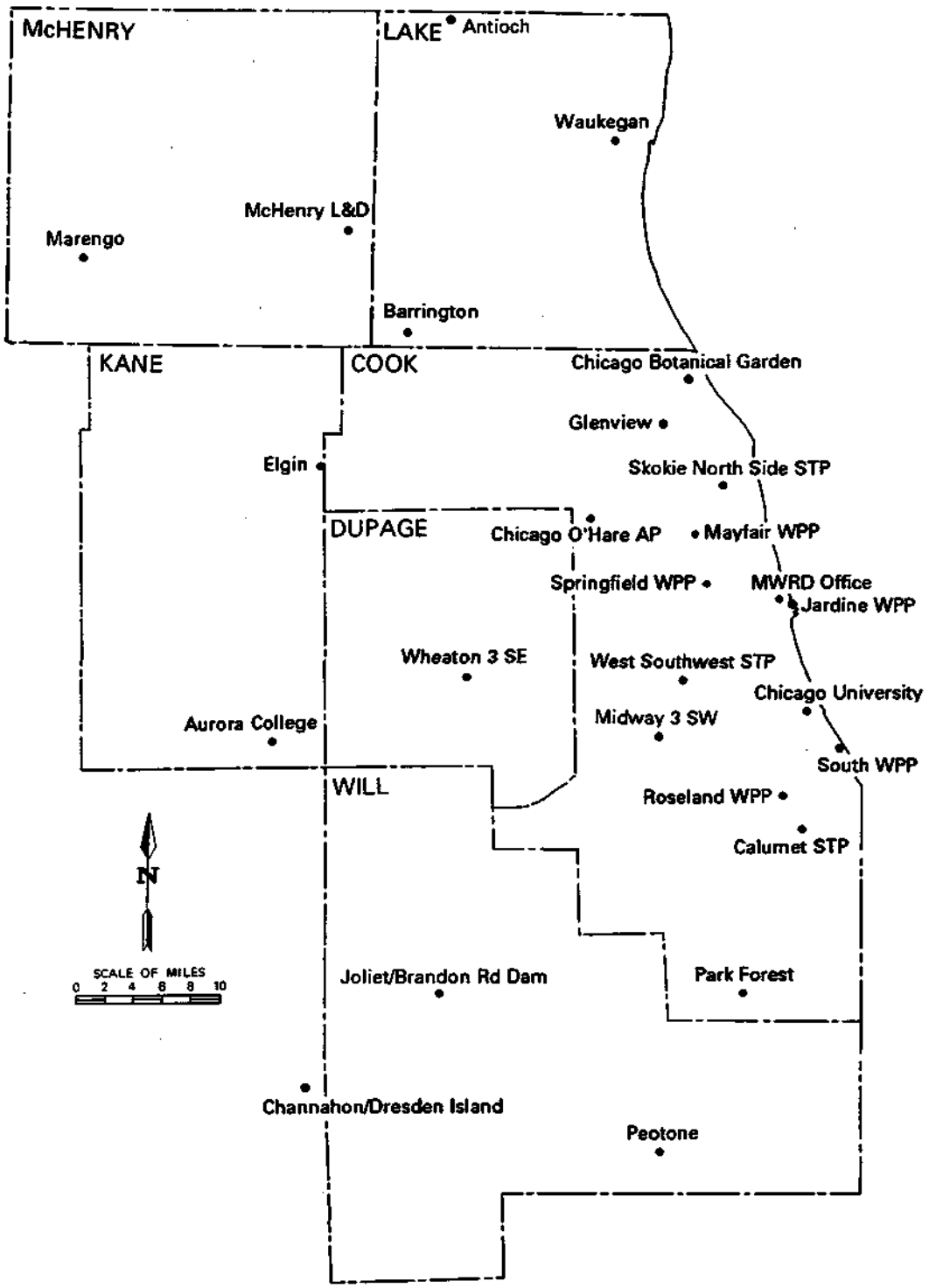

Figure 3. All raingage sites in northeastern Illinois.

Evaluation of Precipitation Data from Water Year 1986

Hourly precipitation values from each recording raingage were organized chronologically with stations as columns and year/month/day/hour as rows. This data matrix was used to check for possible time inconsistencies, and then to divide the data into storm periods. For this study and its predecessors, a storm was defined as a precipitation period separated from preceding and succeeding precipitation events by six hours or more at all stations. This definition has been used successfully by Huff (1967) for an area of similar dimensions in central Illinois, by Vogel (1986) to define extreme storm events in the Chicago area, and by Vogel (1988, 1989) to define storms for Water Years 1984-1985.

Overall, 149 individual storms were defined for Water Year 1986. Each storm was then plotted using all available data, and isohyetal patterns were drawn. The NWS sites, especially Chicago O'Hare Airport, were given the most weight when drawing isohyetal patterns because of exposure problems previously noted at the MWRDGC and CC sites (see Vogel, 1988, for a complete description of the problems at these raingage sites). After a generalized precipitation pattern was obtained for each storm, an adjusted storm amount was estimated at each site either deemed questionable or missing during the storm from the isohyetal pattern. The adjusted storm totals were then partitioned into hourly values using the existing hourly percentage breakdown of the unadjusted data at the sites in question or that of a nearby neighboring station (the latter was used in those cases where missing data were replaced with estimates). Remember that values from additional NWS stations in northeastern Illinois (see Table 1) were used in the analysis to help draw storm patterns. Table 2 gives the adjustments in two forms: inches and percent of change. For Water Year 1986, by far the largest cumulative storm adjustment (Table 2) occurred at the Calumet STP in the southeastern Chicago/Cook County region

Table 2. Cumulative Adjustments and Percent Changes at Raingages Used in Accounting Procedure for Water Year 1986.

Raingage site	Cumulative adjustment (inches)	Percent adjustment
Glenview	+13.35	+27.6
Skokie North Side STP	+ 11.24	+23.7
Erie SDO	+8.30	+21.7
West Southwest STP	+9.19	+20.5
Calumet STP	+ 19.89	+47.5
Mayfair PS	+6.50	+14.5
Springfield PS	+7.50	+ 16.3
South WPP	+3.15	+7.6
Roseland PS	+6.58	+ 14.6
Chicago O'Hare Airport	0.00	0.0
Chicago University	+0.56	+ 1.4
Midway 3 SW	+2.72	+6.1
Park Forest	0.00	0.0

(+19.89 inches, a 47.5% increase). The raingage there has a very poor exposure. Other adjustments of note occurred at Glenview (+13.35 inches/27.6%), Skokie North Side STP (+11.24 inches/23.7%), the MWRDGC Office site (8.30 inches, 21.7%), and West Southwest STP (+9.19 inches/20.5%). All five of these gages are operated by the MWRDGC. No adjustments were made at the NWS Chicago O'Hare Airport and Park Forest sites, both considered accurate. Adjustments at the other two NWS raingages were small, while the adjustments at the four CC gages ranged from 3.15 inches/7.6% (South WPP) to 7.50 inches/16.3% (Springfield WPP).

The final, adjusted Water Year 1986 pattern for the Chicago/Cook County area is given in Figure 4. A general high-precipitation area stretches from the south-central area at Roseland WPP westward and northward through Springfield WPP to Glenview. Low-precipitation areas along the Lake Michigan shoreline were centered on the MWRDGC Office site and the University of Chicago, and in the extreme south on the Park Forest site. Adjusted monthly and water year precipitation amounts for each site are listed in Table 3.

Summary

Data from raingages used to estimate storm runoff in an accounting procedure for Lake Michigan diversion accounting were analyzed for Water Year 1986. As was the case for Water Years 1984-1985, some of the raingages were found to underestimate, sometimes significantly, the precipitation that actually fell. Using a procedure devised by Vogel (1988) for Water Year 1984, adjustments were made to the original 1986 data, and new storm patterns were developed. Estimates were also made at sites where data were missing during the water year. The adjusted data were provided to the Northeastern Illinois Planning Commission in both floppy disk and hard copy formats in 1990.

Acknowledgments

This work was made possible by support from the Illinois Department of Transportation and the U.S. Army Corps of Engineers, Chicago District, under Grant DACW 23-84-M-4067. All Water Year 1986 adjustments were computed by John L. Vogel, Chief, Hydrometeorological Branch, National Weather Service, Silver Spring, Maryland. Phyllis Stone performed computer data entry tasks, and Eva Kingston carefully edited the manuscript.

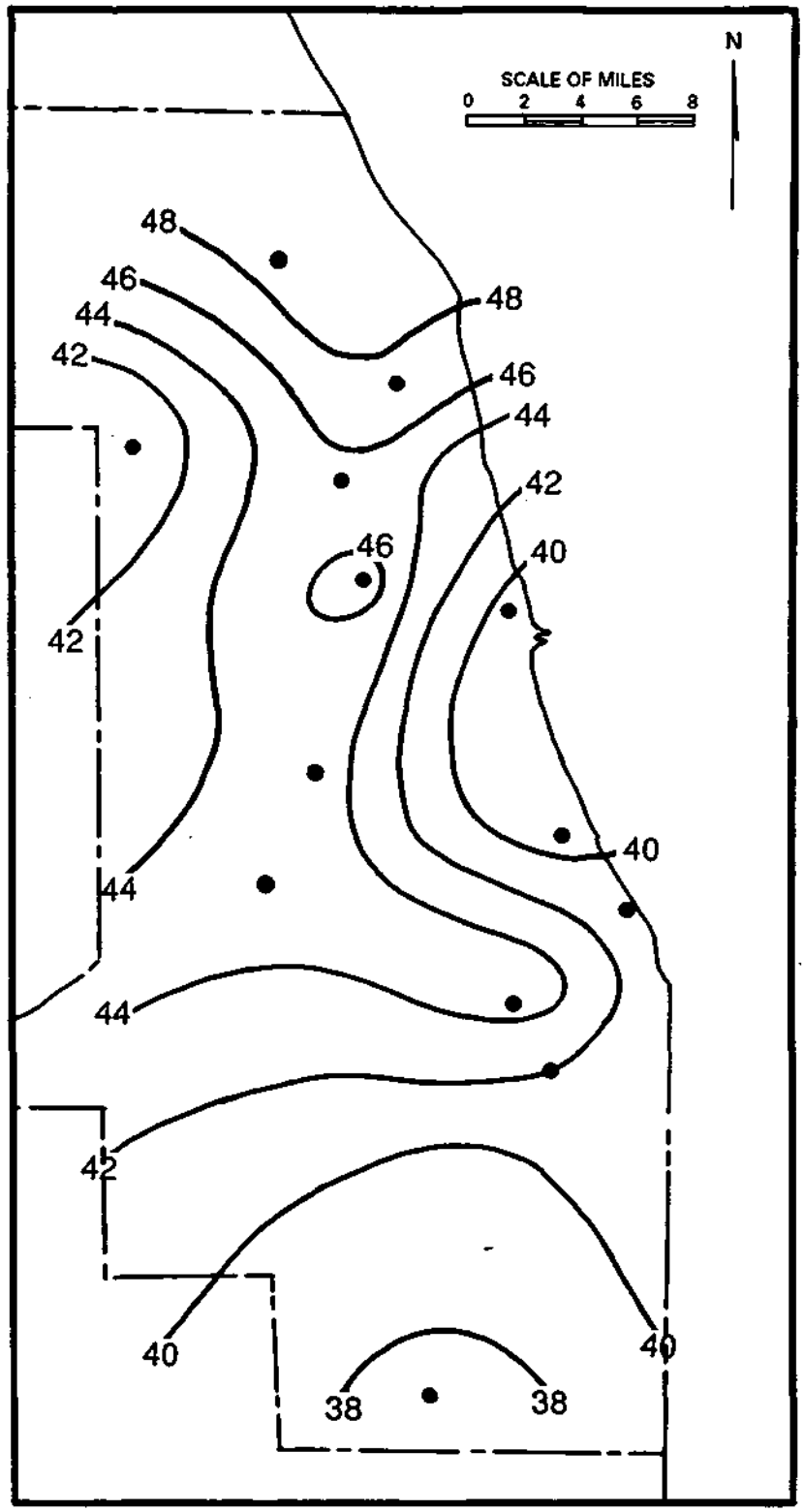

Figure 4. Adjusted Water Year 1986 precipitation pattern (inches).

Table 3. Adjusted Monthly and Water Year Precipitation Amounts for Water Year 1986

	Station												
Month	**ORD**	**MDW**	**WSW**	**MFR**	**SPP**	**ROS**	**CAL**	**UCH**	**SWF**	**SDO**	**SKO**	**GVW**	**PFR**
OCT	4.98	5.77	5.75	4.72	4.91	6.05	5.51	4.77	5.72	3.74	5.17	5.09	3.64
NOV	8.22	7.83	7.30	7.23	7.41	7.66	7.66	6.04	7.15	6.59	7.15	7.41	8.03
DEC	1.49	1.59	1.36	1.44	1.34	1.70	1.71	1.86	1.78	1.24	1.62	1.66	1.69
JAN	0.39	0.50	0.39	0.25	0.28	0.49	0.45	0.66	0.57	0.28	0.23	0.25	0.20
FEB	2.58	2.78	2.84	3.34	3.09	2.77	2.93	3.01	2.77	3.02	3.32	3.19	2.55
MAR	1.49	1.64	1.58	1.59	1.84	1.59	1.57	1.46	1.36	1.52	1.45	1.29	1.50
APR	1.85	1.88	1.98	2.08	1.97	2.07	1.90	2.07	2.10	1.66	2.13	2.00	1.61
MAY	3.11	4.10	4.16	4.79	4.88	3.79	3.49	3.61	3.33	3.75	**4.71**	4.90	3.88
JUN	3.49	4.86	6.36	5.54	5.22	5.59	5.25	5.04	5.70	4.84	5.62	5.30	5.13
JUL	4.30	5.15	5.03	5.18	6.32	5.22	3.73	2.98	3.68	3.64	4.90	5.71	2.97
AUG	1.15	1.30	1.47	1.22	1.34	1.09	0.98	0.85	1.15	1.77	1.55	1.69	1.47
SEP	7.12	7.42	6.66	7.46	7.46	6.92	6.68	6.68	6.41	6.20	9.65	9.86	5.02
TOTAL	40.17	44.82	44.88	44.84	46.06	44.94	41.86	39.03	41.72	38.25	47.50	48.35	37.69

Notes:
ORD = Chicago O'Hare Airport; MDW = Midway 3 SW; WSW = West Southwest STP; MFR = Mayfair PS; SPP = Springfield PS; ROS = Roseland PS; CAL = Calumet STP; UCH = University of Chicago; SWF = South WPP; SDO = MWRDGC Office; SKO = Skokie North Side STP; GVW = Glenview; and PFR = Park Forest

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